A NEW SPECIES OF *OXYURA* (AVES: ANATIDAE) FROM THE NEW ZEALAND HOLOCENE

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A new species of *Oxyura* is described from Holocene age lacustrine deposits at Lake Poukawa, Hawke's Bay, North Island, New Zealand. It is similar to the blue-billed duck *Oxyura australis* Gould from Australia, but is smaller and differs in qualitative features of the major skeletal elements. The previous report of the blue-billed duck *Oxyura australis* from Lake Poukawa is not substantiated by re-examination of all anatid material from the sites. The addition of this new species reveals that 10 species and 7 genera of an original late Holocene fauna of 20 species and 12 genera of waterfowl are now extinct. ❐ Anatidae, *Oxyura vantetsi* sp. nov., blue-billed duck, Lake Poukawa, Holocene, New Zealand

T.H. Worthy, Palaeofaunal Surveys, 2A Willow Park Drive, Masterton, New Zealand; 30 July 2003.

The Holocene avifauna of New Zealand is well known with hundreds of fossil sites distributed throughout the country (Worthy & Holdaway, 2002). Of the 245 species formerly breeding in the New Zealand biogeographic region, 66 are now globally extinct and others exist only as translocated intensively managed populations (Appendix 1, Worthy & Holdaway, 2002). The Anatidae are the most diverse family of land and freshwater birds in the New Zealand region with 18 species in 11 genera breeding in the New Zealand biogeographic region in the Holocene prior to human influence (Worthy & Holdaway, 2002). To this total can be added *Anas rhynchotis* (Gould, 1856), previously excluded as being a recent immigrant, but now known from the Holocene fauna of Lake Poukawa (Worthy, 2004).

A major limitation of the fossil faunas of New Zealand is that relatively few faunas are known from lacustrine deposits – most are from cave, dune, or swamp deposits. In the South Island, the only two lacustrine deposits are Pyramid Valley, which was a small shallow lake (Holdaway & Worthy, 1997; Worthy & Holdaway, 1996), and one on the edge of the large coastal lagoon of Lake Grassmere, in the dune deposits of Marfells Beach (Worthy, 1998). In the North Island, the only lacustrine fauna described is from the Holocene site of N141/XII on the shores of Lake Poukawa (Fig. 1) where some 3500m^2 was excavated by T.R. Price et al., over the period 1966-1975 (Horn, 1983).

The Poukawa deposits have revealed a huge and largely undescribed fauna. Price (1963, 1965) briefly described excavations in Sites I and II in and on the edges of the natural outflow channel from Lake Poukawa. At Site I, about 75m^2 of stream bed and 164m^2 of stream bank and about 115m^2 on the headland were excavated. At Site II, c. 200m^2 of stream bed and adjacent bank were excavated. Price interpreted the faunal deposits on the stream bank and in the stream bed to be primarily associated with the middens on the headland and that people had occupied the area prior to the Waimihia eruption.

This contentious claim was examined by McFadgen (1979) who studied the stratigraphy of site N141/XII which Price considered displayed a similar history of deposition to that seen in sites N141/I&II. McFadgen concluded that the Maori middens indicated occupation on parts of the site 150-300 years ago and that most of the fauna was of natural origin occurring mainly either between the Taupo Ignimbrite (1850 yrs BP) and the Waimihia Tephra (3300 yrs BP), or below the latter (tephra nomenclature and dates follow Froggatt & Lowe 1990). The tephras at Poukawa have been studied by Puller (1965) and Howorth et al., (1980). Environmental studies of the Lake Poukawa palaeovegetation by McGlone (1978) and Pocknall & Millener (1984) also found no evidence of humans in the Poukawa catchment below the Taupo Ignimbrite. Anderson (1989, Appendix B) published a list of nine radiocarbon dates on moa bones from Price's excavations that indicated the deposits extended to at least 7246 years old, supporting the chronology given in Horn (1983).

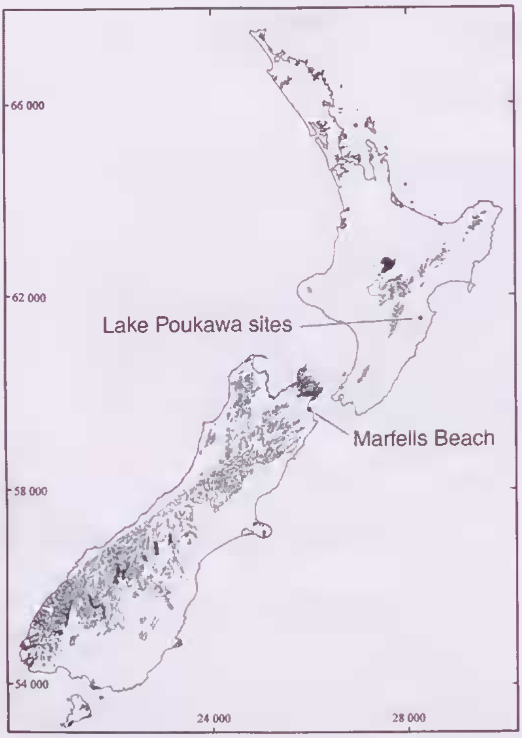

FIG. 1. Location of the sites Lake Poukawa and Wairau Bar, from which *Oxyura vantetsi* are known in New Zealand. The NZMS 260 map grid is indicated on the border (1 square is 400km). The 1000m contour lines are shown.

Despite Price's (1963, 1965) record of substantial faunas from Sites I and II, no analysis of these has yet been published and Horn's (1983) analysis is the only one available for Site N141/XII. However, notable records for some species are known; for example parts of two individual pelicans (*Pelecanus conspicillatus* Temminck, 1824) were found (Scarlett, 1966; Rich & van Tets, 1981; Gill & Tennyson, 2002), and the largest series of the New Zealand musk duck (*Biziura delautouri* Forbes, 1892) was found (Scarlett, 1969; Worthy, 2002).

Horn's (1983) analyses of 12,403 bones of birds other than moas from N141/XII indicated 23 waterbirds, 26 terrestrial species, and four seabirds, making it one of the most diverse faunas ever recorded in New Zealand. Among the taxa listed, the records of *Biziura* and *Mergus australis* Hombron & Jacquinot, 1841 were notable records of rare species. Horn also reported *Oxyura australis* Gould, 1836 (blue-billed duck) and *Dupetor flavicollis* (Latham, 1790) [now *Ixobrychus*] (black bittern) from New Zealand for the first time, though for the latter it was noted that Millener suggested it might belong to *Ixobrychus novaezelandiae* (Potts, 1871) (New Zealand little bittern), and it is to this latter taxon that they are now accepted as belonging (Turbott, 1990; Holdaway et al., 2001).

The possible presence of *Oxyura* in New Zealand was remarkable and little commented on by Horn (1983). While he reported the presence of *Oxyura australis* in both Layer 2 (16 bones) and Layer 3 (4 bones) of Site N141/XII, he unfortunately did not state what bones he referred to *Oxyura*, nor how or for what reason they were so identified. However, Horn acknowledged Dr G. F. van Tets for help in bone identification and it was he who made the identification (Peter Horn, pers. comm. e-mail to THW, 14 May 2002).

The Poukawa collection was subsequently gifted to the National Museum of New Zealand (now Museum of New Zealand Te Papa Tongarewa) by the Hastings Cultural Centre (per Mr Ray Dixon, Director), Mr David Buddo, and Mr Peter Horn in July 1982, and the bones identified and catalogued by Dr Philip R. Millener in 1982-3. He catalogued none as *Oxyura*, though bag labels suggest numbers 22168-178 were first labelled "*Oxyura/Aythya*" before being catalogued as *Aythya*, and so these may have been part of Horn's original *Oxyura* series. Subsequently, Millener (1991: 1329) stated "my examination suggests that the material is more correctly referable to *Aythya*", but he did not indicate which specimens he had considered. Thereafter, *Oxyura* has been dropped from the New Zealand fauna, e.g. Holdaway et al., (2001).

However, Millener had left unidentified several thousand anatid bones. In the course of their reassessment and that of all previously identified anatid bones of all taxa other than *Cygnus* from the entire Poukawa collection, I discovered several bones that did not belong to any known New Zealand species that I subsequently identified as *Oxyura*. In all, 33 humeri, 18 ulnae, 15 femora, 16 tibiotarsi, six tarsometatarsi, 15 coracoids, and two crania were identified as *Oxyura*, and a sternal fragment and a synsacrum as probably *Oxyura*, in the Poukawa collection derived from sites N141/I, N141/II and N141/XII catalogued in the Museum of New Zealand Te Papa Tongarewa. In addition, a single left humerus was located in the Canterbury

TABLE 1. Measurements (mm) of humeri of *Oxyura* species. Modern *Oxyura australis* CM Av31408 and AM O65518 specimens, and summary statistics for fossil *Oxyura vantetsi* sp. nov. from Poukawa (MNZ S 1081, 1115, 2107, 3277, 3370, 3527, 3777, 3778, 4104, 4553, 5915, 8942, 9745, 9746, 10077, 10731, 11218, 11316, 12165, 12425, 12638, 13685, 13686, 13687, 13730, 15650, 15952, 20191, 20228, 20605, 41025, 41259) and CM Av10777.

	Length	PW, tub. dorsale to ventral edge crista bicipitalis	SW, minimum in cranial view	DW, cranial view	Diameter tub. dorsale to jn crista bicipitalis & shaft
Mean	65.50	14.38	4.01	8.72	13.14
Std Error	0.482	0.133	0.035	0.058	0.150
Std Deviation	1.805	0.516	0.183	0.288	0.654
Minimum	61.6	13.5	3.6	7.8	12.0
Maximum	68.4	15.5	4.4	9.3	14.4
Count	14	15	27	25	19
CMAv10777	64.5	14.4	3.9	8.9	13.7
CM Av31408	73.8	15.8	4.1	10.2	14.6
AM O65518	72.6	15.6	3.8	10.0	15.0

Museum Christchurch (CM Av10777) that has no locality data preserved with it. However, the presence of mica flakes in the dirt covering parts of the bone indicates a South Island origin for the specimen, and its preservation (colour of staining and presence of shallow rootlet grooves) is similar to material from middens preserved in the alluvial sediments of the Wairau Bar river mouth near Blenheim (pers. obs.).

Study of these *Oxyura* bones indicated consistent differences for all specimens of each element between them and recent specimens of *O. australis*. Here I describe this material as a new species and present extensive comparisons with the most similar sympatric species in New Zealand, *Aythya novaeseelandiae* (Gmelin, 1789), to facilitate its future identification.

METHODS

The following abbreviations are used throughout the text.

INSTITUTIONS. AM, Australian Museum, Sydney, Australia; CM, Canterbury Museum, Christchurch, New Zealand; MNZ, Museum of New Zealand Te Papa Tongarewa, Wellington (formerly National Museum of New Zealand, Dominion Museum, and Colonial Museum), NZ.

SKELETAL ELEMENTS AND DESCRIPTIVE TERMS. The following abbreviations apply to single and plural usage of the elements. Cor, coracoids; Fem, femora; Hum, humeri; subad, subadult; Tmt, tarsometatarsi; Tib, tibiotarsi. When listing material, bilateral elements are identified as left (L) or right (R) sides. L or R prefixed by ‘p’, ‘s’, or ‘d’ indicates ‘proximal’, ‘shaft’, or ‘distal’ part of the element respectively, e.g., pR fem means the proximal part of a right femur.

Anatomical nomenclature for specific bone landmarks follows Baumel & Witmer (1993). Some common terms are abbreviated as follows: artic. for articularis; cond. for condylus; proc. for processus; tub. for tuberculum.

MEASUREMENTS. Values were obtained with Tesa® dial callipers and rounded to 0.1mm. TL: greatest length, except for the coracoid, which was measured down the medial side, and femora, which were measured from the proximal end of the crista trochanteris to the cond. lateralis. PD: the proximal depth of femora was measured through the crista trochanteris. PW: proximal width in the lateromedial plane; femora were measured from the caput femoris through the mid-depth point of the neck to the lateral side. SW: shaft width at mid-length (unless otherwise stated, when it may be a minimum value e.g. SW min) in a lateromedial plane. SD: shaft width in a dorsoventral plane (depth) at the point SW was taken. DW: distal width. Tibiotarsi AL: length measured from the proximal articular surfaces to the cond. lateralis. Tibiotarsi PW: measured across the articular surface. Tarsometatarsus DW was measured with one side of the calliper along the lateral side.

COMPARATIVE MATERIAL. All material is from modern skeletons.

Oxyura australis Gould, 1836 Blue-billed duck: CM Av31408, Lake Cowal, New South Wales, Australia; AM O65518, Taronga Zoo, Australia. *Aythya novaeseelandiae* (Gmelin, 1789) New Zealand

TABLE 2. Measurements (mm) of ulnae of *Oxyura* species. *O. australis* CM and AM specimens, and summary statistics for *O. vantetsi* nsp (specimens MNZ S2398, 4512, 5316, 8653, 9727, 10917, 11118, 11634, 12107, 15697, 16618, 16732, 18178, 19128, 20617, 20180, 22179). Abbreviations as in Methods.

	Length	PW, cranial view	Mid SW cranial view	Min DW cran view	Caudal diam cond. dorsalis ulnaris	Max DW
Mean	55.55	6.15	3.45	3.89	5.67	6.52
Std Error	0.468	0.111	0.054	0.076	0.090	0.119
Std Deviation	1.750	0.384	0.207	0.304	0.347	0.476
Minimum	51.2	5.4	3.0	3.3	4.9	5.6
Maximum	58.3	6.6	3.9	4.4	6.1	7.0
Count	14	12	15	16	15	16
CM Av31408	60.97	6.64	3.35	4.54	6.00	6.50
AM O65518	60.92	6.42	3.25	4.70	6.04	6.72

scaup: CMAv22382; CMAv22413; MNZ 8726; MNZ 13685; MNZ 16588; MNZ 16589; MNZ 17001; MNZ 17002; MNZ 17003; MNZ 23144; MNZ 24245. *Aythya australis* (Eyton, 1838) Australian white-eyed duck: AM O65772, New South Wales, Australia. *Aythya affinis* (Eyton, 1838) lesser scaup: MNZ 24041, Michigan, USA.

Examples of all other anatids mentioned were examined in the collections of the MNZ.

SITE LOCALITIES. In the specimen lists, Sites N141/I, N141/II, and N141/XII are given as I, II, and XII, respectively. All were collected by T. R. Price *et al.*, at various dates in the 1960s and 1970s as catalogued. I use the nomenclature on the labels with respect excavation depth, e.g. ‘< Taupo’, to avoid interpretation error. But I believe that ‘<’ means ‘below’ and ‘>’ means ‘above’ the respective tephra in the excavated section. Depth is indicated in inches or as Layer as recorded by the excavators. I note that a sample is unlikely to come from a specific depth, but rather a depth range in the excavation, and so it is probable each bag lot, from which all bones have been catalogued in a series, actually comes from a depth range that is to the stated value from the depth where the preceding spit ended in the same square. Establishment of the correctness or otherwise of this interpretation has not been attempted. This is significant for samples that have data such as ‘2" <Taupo’, most likely could actually mean from ‘1" >Taupo to 2" < Taupo’.

Sites N141/I and N141/II are located near Lake Poukawa, Hawke’s Bay, New Zealand at NZMS 260 series map reference V22/296525 or 39°46’24”S, 176°43’54”E. Site N141/XII is at the map reference V22/283523, or 39°46’34”S, 176°43’0”E.

AGE OF HOLOTYPE

The holotype was found below the Taupo Ignimbrite and is therefore older than 1850 yrs BP. It is likely to be younger than the Waimihia tephra (3300 yrs BP, Froggatt & Lowe, 1990) as that tephra was not mentioned and all material was related to either Taupo or Waimihia tephras, the latter when samples were from below it. All Poukawa specimens are from the peat deposits or overlying sediments, and as peat deposition began about 6500 yrs BP (McGlone, 2002), all the material can be considered mid- to late-Holocene in age.

SYSTEMATIC PALAEONTOLOGY

Class AVES

Order ANSERIFORMES (Wagler, 1831)

Family ANATIDAE Leach, 1820

Subfamily OXYURINAE (Phillips, 1926)

Oxyura Bonaparte, 1928

The holotypic humerus described below is referred to *Oxyura* as it shares with members of the genus the following combination of characters: 1, closed fossa pneumotricipitalis; 2, tub. dorsale is much elevated above the shaft; 3, the caudal surface of the caput humeri is deeply excavated between the tub. dorsale and the incisura capitis; 4, the incisura capitis is blocked by a low ridge at its dorsal end; 5, the crus dorsale fossae (proximal margin of the pneumotricipitalis) in caudal aspect is directed distally relative to the alignment of the shaft; 6, the shaft narrows markedly distally with minimum width near the distal end; 7, the tub. supracondylare ventrale is large, and extends proximad of the cond. dorsalis and its flat face is parallel to the shaft; 8, the attachment point of the M. pronator superficialis is not distinct, having merged with

TABLE 3. Measurements (mm) of coracoids of *Oxyura* species. *O. australis* CM and AM specimens, and summary statistics for *O. vantetsi* (specimens MNZ S3363, 3781, 8933, 9444, 11212, 11404, 12163, 13722, 13773, 16176, 16972, 18056, 22439). Abbreviations: fac. artic. hum., facies articularis humeralis; cotyla scap., cotyla scapularis; proc. acro., processus acrocoracoideus

	Length (internal)	Length fac. artic. hum.	Width fac. artic. hum.	Length cotyla scap. to proc. acro.	Shaft width	Width fac. artic. sternalis
Mean	36.72	7.15	4.56	10.70	3.82	16.31
Std Error	0.492	0.072	0.060	0.112	0.059	0.306
Std Deviation	1.476	0.269	0.223	0.355	0.219	0.809
Minimum	34.6	6.8	4.2	10.1	3.5	15.1
Maximum	38.3	7.9	4.9	11.2	4.1	17.2
Count	9	14	14	10	14	7
CM Av31408	41.5	8.0	5.2	12.2	4.1	18.1
AM O65518		7.5	4.8	11.7	3.9	17.7

the margin of the tub. supracondylare ventrale; 9, the fossa m. brachialis is deep with a narrow ridge defining its ventral margin.

All species examined in *Anas*, *Hymenolaimus*, *Chenonetta*, *Mergus*, *Nettapus*, *Tadorna*, and *Dendrocygna* differ in many ways, not least of which is that all have an open fossa pneumotricipitalis. Both *Malacorhynchus membranaceus* (Latham, 1801) and *M. scarletti* Olson, 1977 have a closed fossa pneumotricipitalis but greatly differ in having a marked capital shaft ridge and the shaft has equal diameter along its whole length. *Biziura*, uniquely among the taxa examined here, shares with *Oxyura* the absence of a distinct attachment point of the M. pronator superficialis. However, both *Biziura lobata* (Shaw, 1796) and *B. delautouri* are larger and the humerus is much more elongate with a marked capital shaft ridge and the caput humeri is not deeply excavated between the tub. dorsale and the incisura capitis caudally. *Aythya* differs from *Oxyura* in several ways, notably that the tub. dorsale is not raised above the shaft, the attachment point of the M. pronator superficialis is distinct, and the caput humeri is not deeply excavated between the tub. dorsale and the incisura capitis caudally. Other differences are detailed below.

Oxyura vantetsi sp. nov.
(Figs 2-9; Tables 1-7)

MATERIAL. HOLOTYPE MNZ S108; Site N141/XII, Square 4K, < [below] Taupo Ignimbrite, Lake Poukawa, Hawke's Bay, New Zealand. Map reference: NZMS 260 series, V22/283523, and 39°46'34"S, 176°43'0"E. Collected by T. R. Price et al., 20 November, 1967. A complete and unworn left adult humerus that is unmineralised, although it is stained brown, and has some adhering sediment in grooves. PARATYPES. Poukawa, Sites N141/I, N141/II, and N141/XII: MNZ S3370, R Hum; Site XII, Sq. 3J, Layer 2, 13 April, 1968; MNZ S3527, R Hum; Site XII, Sq. 21 (SE), Layer 5, 3 June, 1967; MNZ S5915, L Hum, Site XII, Sq. 10 (NE), 18" < Taupo, 6 Sept., 1969; MNZ S9745, L Hum; Site XII, Sq. 4B (NW-NE), base *Hyridella* midden, 4 June, 1966; MNZ S12165, L Hum; Site XII, Sq. 5G (NW), 7" < Taupo, 28 Oct., 1972; MNZ S13730, R Hum; Site XII, Sq. 10F (NE), on Taupo, 14 Oct., 1972; MNZ S20605, R Hum; Site II, Sq. 12C, Totara Point, 15 June, 1963;. REFERRED MATERIAL. *Humeri* MNZ S1115, L Hum, XII, Sq. 11 (SW), 8" <Taupo; S2107, dL Hum, XII, Sq. 5H (NE), 2-3" <Taupo; S3277, pR Hum, XII, Sq. 6J, Layer 3; S3777, L Hum, XII, Sq. 5I (NW), <Taupo; S3778, d+sR Hum, XII, Sq. 5 (NW), <Taupo; S4104, dR Hum, XII, Sq. 11 (NE), >Waimihia; S4553, dL Hum, XII, Sq. 4C, Layer 5; S8942, pR Hum, XII, Sq. 17 (NW-SW), 4" <Waimihia; S9746, pL Hum, XII, Sq. 4B (NW-NE), base *Hyridella* midden; S10077, L Hum, XII, Sq. 86, sub 3-4, 14" <Waimihia; S10731, R Hum, XII, Sq. 4H(NE), 3-4" <Taupo; S11218, R Hum, XII, Sq. 19C (SE), 1" >Taupo; S11316, dL Hum, XII, Sq. 20B (NW), 2" <Taupo; S12425, R Hum, XII, Sq. 25A (NW), in Waimihia; S12638, L Hum, XII, Sq. 25C (SW-SE), with Taupo; S13685, L Hum, XII, Sq. 10F (SW), 1" >Taupo; S13686, dL Hum, XII, Sq. 10F (SW), 1" >Taupo; S13687, dR Hum, XII, Sq. 10F (SW), 1" >Taupo; S15650, R Hum, XII, Sq. 21H (NE), 9" <Taupo; S15952, R Hum, XII, Sq. 22G (SE), 9" <Taupo; S20191, dL Hum, II, Sq. 24B, long grid base, Totara Point; S20228, pL Hum, II, Sq. 9A, long grid base, Totara Point; S41025, L Hum, Poukawa, site unknown; S41259, L Hum, II, #89, square and layer details lost; S41288, pR Hum, XII, Sq. 1H (NE); CMAv10777, L Hum, mica

FIG. 2. Humeri of *Oxyura* species compared with *Aythya novaeseelandiae*. A, left humerus MNZ S1081, Holotype *Oxyura vantetsi*; B, right humerus S13730 *O. vantetsi*; C, right humerus *O. australis* CM Av31408; D, right humerus *Aythya novaeseelandiae* MNZ 24245. Upper row – proximal end, caudal view; middle row – cranial view; lower row – ventral view of epicondylus ventralis on distal end.

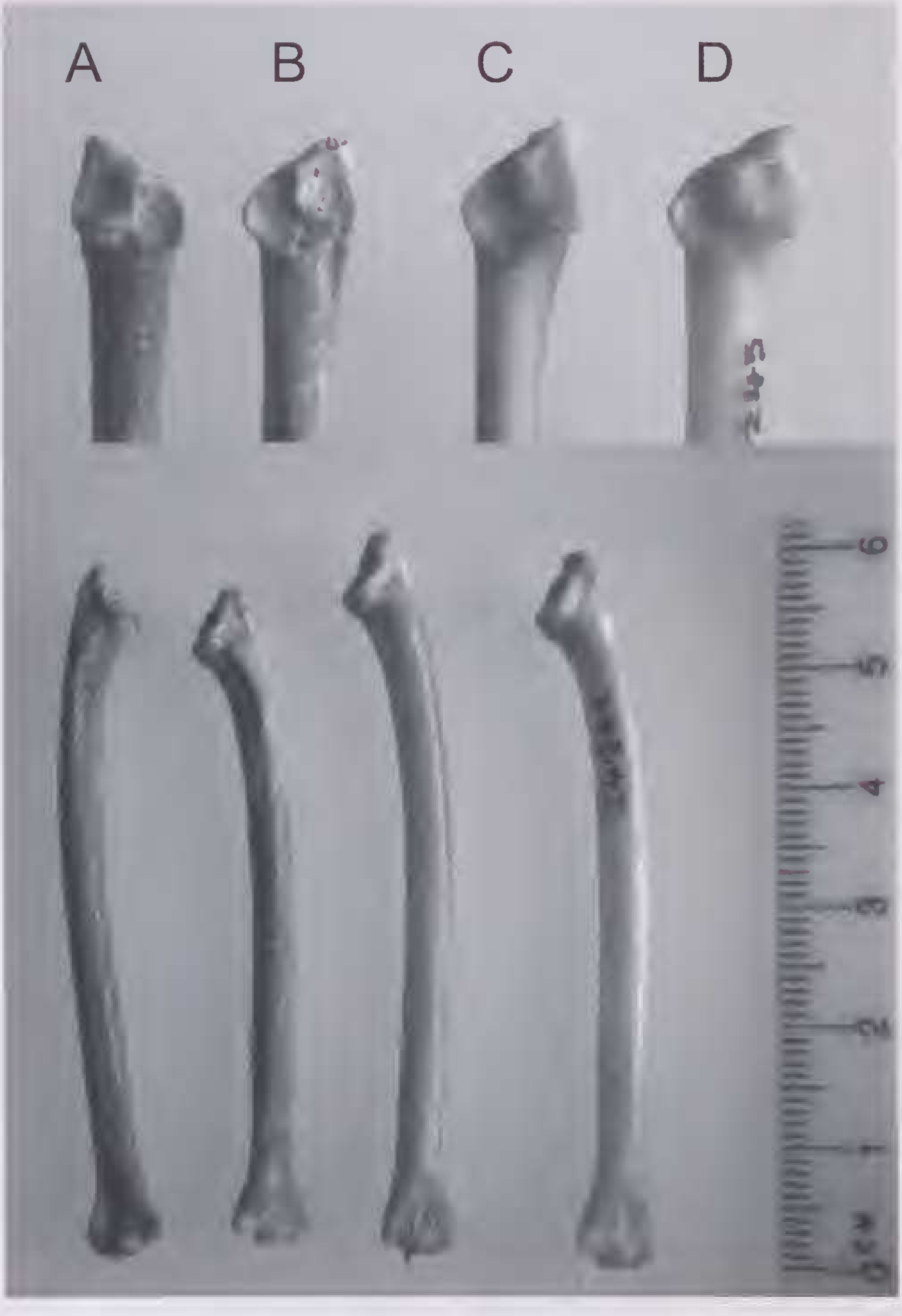

FIG. 3. Ulnae of *Oxyura* species compared with *Aythya novaeseelandiae*. A, *O. vantetsi* left ulna S8653; B, *O. vantetsi* right ulna S5316; C, *O. australis* CM Av31408; D, *Aythya novaeseelandiae* MNZ 24245. Upper row, proximal end in cranial aspect, lower row in ventral aspect.

TABLE 4. Measurements (mm) of femora of *Oxyura* species. *O. australis* CM and AM specimens, and summary statistics for *O. vantetsi* (specimens MNZ S1082, 1091, 4515, 5976, 10436, 10437, 11739, 11741, 12855, 13635, 13809, 16696, 17025, 18288). Abbreviations as in Methods.

	Length	PW	PD	SW min	SD	DW	Distal depth (of cond. lateralis)
Mean	41.28	10.07	7.12	3.77	4.76	10.20	7.90
Std Error	0.214	0.049	0.085	0.029	0.031	0.076	0.127
Std Deviation	0.741	0.183	0.280	0.107	0.114	0.229	0.381
Minimum	40.1	9.7	6.6	3.6	4.5	9.7	7.4
Maximum	42.7	10.3	7.4	4.0	4.9	10.6	8.5
Count	12	14	11	14	14	9	9
CM Av31408	45.8	11.5	7.7	3.9	4.7	10.9	9.0
AM O65518	45.5	10.7	7.0	3.6	5.0	10.6	8.7

indicates South Island origin. It is similar to some Wairau Bar material.

Ulnae. MNZ S2284, dL ulna, XII, Sq. 9K (SW), <Taupo; S2398, R Ulna, XII, Sq. 3H, Layer 1B; S4512, R Ulna, XII, Sq. 8C (NE), Layer 5; S5316, R Ulna, XII, Sq. 7H (SW), 6-10" <Taupo; S8653, L Ulna, XII, Sq. 15A (NW); S9727, L Ulna, XII, Sq. 4A (NW-NE), 4" <Taupo; S10917, L Ulna, XII, Sq. 4H (SW), Layer 3, just >Taupo; S11118, L Ulna, XII, Sq. 19 (SE), 18" <surface; S11634, L Ulna, subad, XII, Sq. 2J (NE), 4" <Taupo; S12107, dR Ulna, XII, Sq. 5B (SE), <Taupo; S15697, L Ulna, XII, Sq. 21H (NW), 2" <Taupo; S16618, dR Ulna, XII, Sq. 24F (SE), 2" <Taupo; S16732, L Ulna, XII, Sq. 24G (SW), 3" <Taupo; S18178, R Ulna, II, Sq. 11B, long grid base; S19128, R Ulna, II, Sq. 4A, Totara Point; subad; S20180, L Ulna, II, Sq. 21C, long grid base; S20617, R Ulna, II, Sq. 12G, Totara Point; S22179, R Ulna, XII, Sq. 1H, >Taupo.

Femora. MNZ S1082, R Fem, XII, Sq. 4K, <Taupo; S1091, R Fem, XII, Sq. 5K (SE); S4515, L Fem, XII, Sq. 8C (NE), Layer 5; S5976, L Fem, XII, Sq. 10 (NW), 4" <Waimihia; S10436, L Fem, XII, Sq. 811 sub 3, 3" <Waimihia; S10437, R Fem, XII, Sq. 811 sub 3, 3" <Waimihia; S11739, L Fem, XII, Sq. 2J (SE), 4" <Taupo; S11741, R Fem, XII, Sq. 2J (SE), 4" <Taupo; S12855, L Fem, XII, Sq. 26C (NE), in Taupo; S13635, L Fem, XII, Sq. 10E (NW), 7" <Taupo; S13809, R Fem, XII, Sq. 11 (NE), > Waimihia; S16696, R Fem, XII, Sq. 24G (NE), 2" <Taupo; S17025, R Fem, I, Sq. 5 short grid; S18288, L Fem, II, Sq. 7C, long grid base; S41296, pL Fem, XII, Sq. 1H baulk.

Tibiotarsi. MNZ S1083, R Tib, XII, Sq. 4K, <Taupo; S2247, sL Tib, XII, Sq. 8K (NE), 4" <Taupo; S4298, L Tib, XII, Sq. 3K (SE), > third ash; S5776, pL Tib, XII, Sq. 3H (NE), Layer 3; S8348, R Tib, XII, Sq. 6G (NE), 2" <Taupo; S9632, L Tib, XII, Sq. 4H (NW), 1" >Taupo; S9976, pL Tib, XII, Sq. 83, <Taupo; S12596, dR Tib, XII, Sq. 25C (NW-NE), 2" <Taupo; S13688, pL Tib, XII, Sq. 10F (SW), 1" >Taupo; S16540, pR Tib, XII, Sq. 23F (SW), 4" <Taupo; S22170, pR Tib, Poukawa site, data lost; S22172, R Tib, Poukawa site, data lost; S22173, R Tib, Poukawa site, data lost; S22174, pL Tib, Poukawa site, data

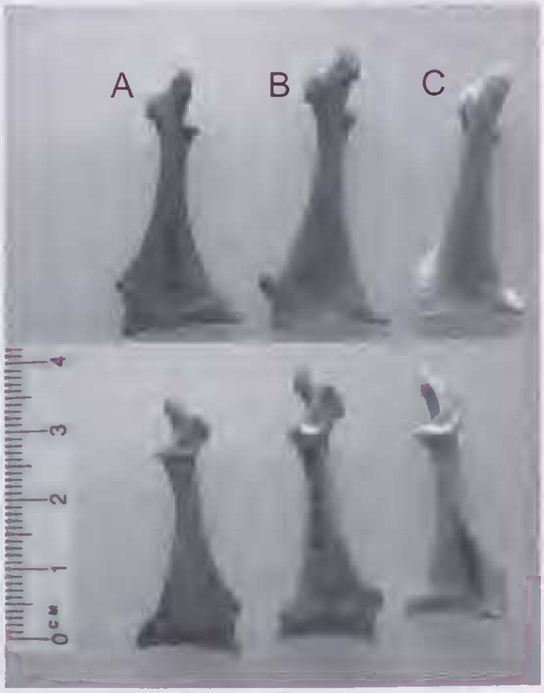

FIG. 4. Right coracoids of *Oxyura* species compared with *Aythya novaeseelandiae*. A, *O. vantetsi*, MNZ S18056; B, *O. australis* CM Av31408; C, *Aythya novaeseelandiae* MNZ 24245. Upper row, ventral aspect; lower row, dorsal aspect.

lost; S22175, L Tib, Poukawa site, data lost; S41453, sL Tib, XII, Sq. 25C (NW-NE), 2" <Taupo.

Tarsometatarsi. MNZ S8684, sL Tmt, XII, Sq. 15A (SW), 5-8" <Taupo; S13358, sR Tmt, XII, Sq. 2G (SE), >subsoil; S14692, R Tmt, XII, Sq. 3B (SW), <Taupo; S22176, R Tmt, Poukawa site, data lost; S22177, R Tmt, Poukawa site, data lost; S22178, L Tmt, Poukawa site, data lost.

Coracoids. MNZ S3363, R Cor, XII, Sq. 3J, Layer 2; S3781, L Cor, XII, Sq. 51 (NW), <Taupo; S8933, R Cor, XII, Sq. 17 (NW-SW), 4" <Waimihia; S9444, R Cor, XII, Sq. 4D (SE), Layer 1; S11212, R Cor, XII, Sq. 19C (SE), 1" >Taupo; S11404, R Cor, XII, Sq. 20I (NE), on Taupo; S12603, R Cor, XII, Sq. 25C (NW/NE), 2" <Taupo; S12163, L Cor, XII, Sq. 5G (NW), 2" <Taupo; S13722, L Cor, slightly immature, XII, Sq. 10F (NE), on Taupo; S13773, R Cor, XII, Sq. 10F, 9" <Taupo; S16176, R Cor, XII, Sq. 6B (NE), 2" <Taupo; S16972, L Cor, I, Sq. 4A, short grid; S18056, R Cor, II, Sq. 6A, long grid base; S22439, L Cor, XII, Sq. 87 east baulk, <Waimihia, in peat; S41408, R Cor, II, Sq. 1A-12A.

Cranial material. MNZ S41197, complete cranium, Poukawa site, data lost; S20222, posterior half of cranium, II, Sq. 9A, long grid base.

Sternum. MNZ S41330, anterior part, XII, Sq. 1H (NE).

ETYMOLOGY. The species is named after Dr Gerard (Jerry) Frederick van Tets (1929 - 1995).

MEASUREMENTS OF THE HOLOTYPE. Total length 66.24 mm, proximal width tub. dorsale to ventral edge crista bicipitalis 14.40 mm, shaft width minimum in cranial view 3.86 mm, distal width in cranial view 9.00 mm, Diameter tub. dorsale to junction of crista bicipitalis and shaft 13.74 mm.

DIAGNOSIS. *Oxyura* that is smaller than *Oxyura australis* (Table 1), and from which it differs by the following characters of the humerus: the epicondylus ventralis is shorter distally of the tub. supracondylare ventrale resulting in a wider angle between the caudal and distal margins of the epicondylus ventralis; there is a ridge running from the tub. dorsale down the caudal surface of the shaft at the base of the crista deltopectoralis creating a concave surface between the distal end of the ridge and the crista deltopectoralis (ridge absent in *O. australis* and comparable surface concave); the fossae pneumotricipitalis viewed from the distal end appears circular (not wider than deep).

DESCRIPTION AND COMPARISON. *Humerus* (Fig. 2) Humeri of *Oxyura vantetsi* differ from those of *O. australis* as described in the diagnosis. Among waterfowl in New Zealand they are most similar to those of *Aythya novaeseelandiae* which are slightly larger (Appendix 1) and also have a closed fossa pneumotricipitalis. However, in *Aythya novaeseelandiae*, the tub. dorsale is much less elevated; the caput humeri is less excavated under it caudally; the shaft lacks the marked narrowing distally seen in *Oxyura*; there is no ridge across the incisura capitus; the crista

FIG. 5. Left femora of *Oxyura* species compared with *Aythya novaeseelandiae*. A, *O. vantetsi* MNZ S18288; B, *O. australis* CM Av31408; C, *Aythya novaeseelandiae* MNZ 24205. Upper row in caudal aspect; lower row in lateral aspect.

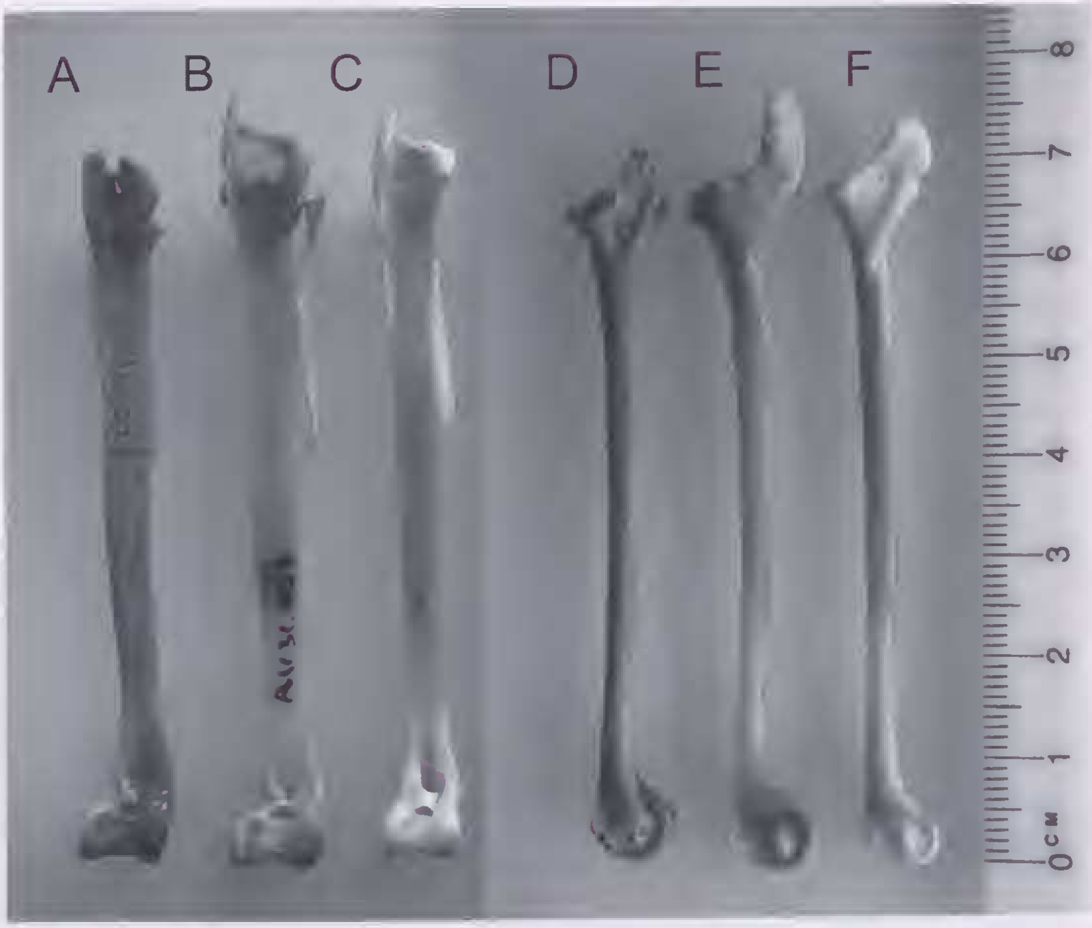

FIG. 6. Tibiotarsi of *Oxyura* species compared with *Aythya novaeseelandiae*. A,D - *O. vantetsi* MNZ S22175; B,E - *O. australis* CM Av31408; C,F – *A. novaeseelandiae* MNZ 24205. A-C in cranial aspect; D-F in medial aspect.

bicipitalis deviates from the shaft at a much shallower angle; the crus dorsale fossae is aligned at right angles to the shaft; the tub. supracondylare ventrale is smaller, not extending proximad of the cond. dorsale and its face is directed distally, and there is a distinct attachment point centrally placed in the ventral facies for the M. pronator superficialis.

Ulna (Fig. 3). To detect the ulnae of *Oxyura vantetsi* in the Poukawa collections I predicted their likely length range from the lengths of the humeri assuming that the humerus-ulna ratio of bone lengths for *Oxyura vantetsi* was similar to that of *O. australis* (i.e. 0.826, 0.839), which is slightly smaller than in *A. novaeseelandiae* (mean = 0.849, sd =0.0108 , n= 10). As humeri of *Oxyura vantetsi* ranged from smaller than to about the same length as small to average-sized *A. novaeseelandiae*, e.g. MNZ 24245, it was expected that their ulnae would be shorter than those of *A. novaeseelandiae*. Examination of all ulnae with the general straight slender form of either *Oxyura* or *Aythya* revealed two size groupings. There were those typical of *A. novaeseelandiae* ranging from 58-63mm long compared to 59.3-63.2mm in a modern sample (Appendix 1), but there was a distinct grouping of fossil ulnae less than 58mm long (Table 2).

These smaller ulnae had a markedly shorter cond. dorsalis ulnaris approaching the condition seen in *O. australis*, rather than it being markedly longer than wide as in *Aythya novaeseelandiae*, and so were referred to *O. vantetsi*. In general, ulnae referred to *O. vantetsi* are relatively slender

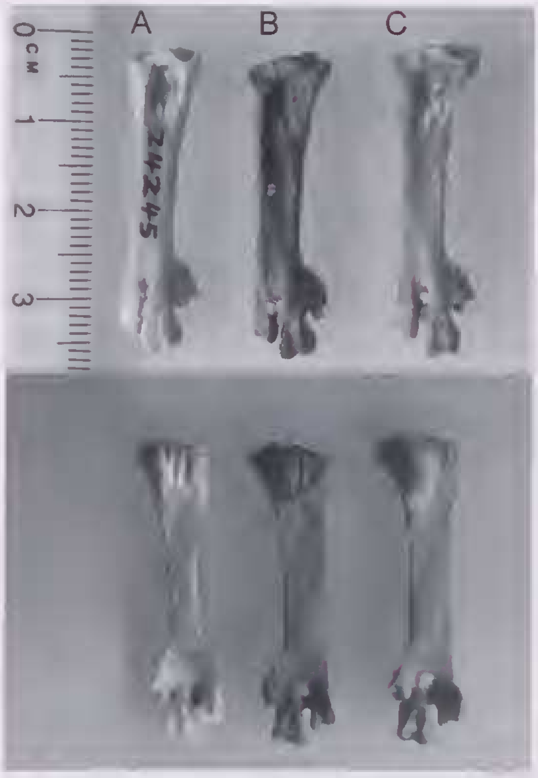

FIG. 7. Right tarsometatarsi of *Oxyura* species compared with *Aythya novaeseelandiae*. A, *Aythya novaeseelandiae* MNZ 24205; B, *O. vantetsi* MNZ S22177; C, *O. australis* CM Av31408. Upper row in dorsal aspect; lower row in plantar aspect.

FIG. 8. Right tarsometatarsi of *Oxyura* species compared with *Aythya novaeseelandiae*. A, *Aythya novaeseelandiae* MNZ 24205; B, *O. vantetsi* MNZ S22177; C. *O. australis* CM Av31408. Upper row in lateral aspect; lower row in medial aspect.

with a shaft that tapers to a least width near the distal end in ventral or cranial view, and that have small proximal and distal ends, and so are similar to those of *A. novaeseelandiae*. They are distinguished by the following combination of characters. Length 51-58mm (Table 2). In ventral view, the caudal margin of the shaft forms a straight line extending over half the bone length from the distal end. The olecranon is small, pointed and not raised much above the cotyla ventralis. The ventral margin of the ventral cotyla is straight and forms a near right angle with the cranial margin. The impressio brachialis is deeply excavated, and in ventral aspect extends beyond half of the bone depth towards the caudal facies. The cond. dorsalis ulnaris, in caudal aspect, is rounded, with the cranial-caudal width only slightly less than its length (length longer than width in *A. novaeseelandiae*). The tub. carpale is narrow ventrodorsally and so is less robust than it is in *A. novaeseelandiae*. The depressio radialis is deeper than it is in *Aythya novaeseelandiae*.

Ulnae of *Oxyura australis* are bigger, but otherwise similar in shape to those of *O. vantetsi*. However, the cond. dorsalis ulnaris is wider craniocaudally than it is long and is markedly stepped up from the shaft on its proximal margin.

Coracoid (Fig. 4). Fourteen coracoids (Table 3) were referred to *Oxyura vantetsi* because of their similarity to those of *O. australis*. Coracoids of *O. vantetsi* share the following characters with *O. australis* and differ from the most similar species of New Zealand waterfowl *Aythya novaeseelandiae* by the following characters. They have a small humeral end and a disproportionately wide sternal end. The proc. acrocoracoideus is small and does not overhand the shaft medially. The dorsal part of the facies artic. clavieularis forms a small protuberance that does not extend sternally as a sharp spike into the sulcus m. supracoraeoideus (unlikc *A. novaeseelandiae* in which it forms a sharp spike interrupting the suleus). The faeies artie. humeralis is short and broad, with an abrupt step to the shaft adjacent to the cotyla scapularis (unlike *Aythya* in whieh it is relatively narrower and slopes to the shaft). The sulcus m. supraeoracoidei is not exeavated under the facies artic. humeralis (unlike *Aythya* in whieh it is deeply exeavatcd). There is a short proc. lateralis (unlike *Aythya* which has none). The angulus medialis has a broad flange leading to it so that the angle in dorsal aspect is about 60° (unlikc *A. novaeseelandiae* in which the medial angle tapers to a point at about 30°). The facics artie. sternalis is broad with a prominent centrally loeatcd ridge bounding it dorsally aeross the width (unlike *Aythya* in which it is narrower and the bounding ridge is offset medially). With a length range of 34.6-38.3mm, coraeoids of *O. vantetsi* are smaller than in *O. australis* (Table 3), but have an overlapping length range with those of *Aythya novaeseelandiae* (Appendix 1).

Femur (Fig. 5.) Fifteen femora were referred to *Oxyura vantetsi*. These femora are superficially similar to those of *Aythya* as follows. They have a similar length (Table 4, Appendix 1) and the shaft is narrower than deep and bent caudally over its distal third as in *O. australis* and *A. novaeseelandiae*, but unlike all species of *Anas* in whieh it is straight and tends to be round in section. The depth through the crista trochanter is only slightly more than the depth of the ball, as in *Aythya*, but unlikc all *Anas* specics, in which the depth of the trochanter is markedly greater. The fossa poplitca is deep and bound by a compressed ridge medially as in both *Oxyura* and *Aythya*.

However, the rcferred femora are similar to *O. australis* and differ from the superficially similar femora of *Aythya* as follows. Both the proximal and distal cnds are much more robust than in *Aythya*. There is a distinct prominenee on the faeies lateralis level with the end of the crista trochanteris, which is absent in *Aythya*. The proximoeaudal part of the cond. medialis in medial aspcet conneets to the shaft at right anglcs rather than as a slope as in *Aythya*. The crista tibiofibularis is large and in lateral view forms a large step from the shaft (smaller in *Aythya*). The proximal margin of the troehlea fibularis in lateral aspeet forms a distinct flat ledge aligned at right angles to the shaft and whieh extends to half of the shaft dcpth before merging with it. In *Aythya*, the trochlea fibularis is smaller and slopes proximally before merging at about one third of shaft depth from the caudal surface.

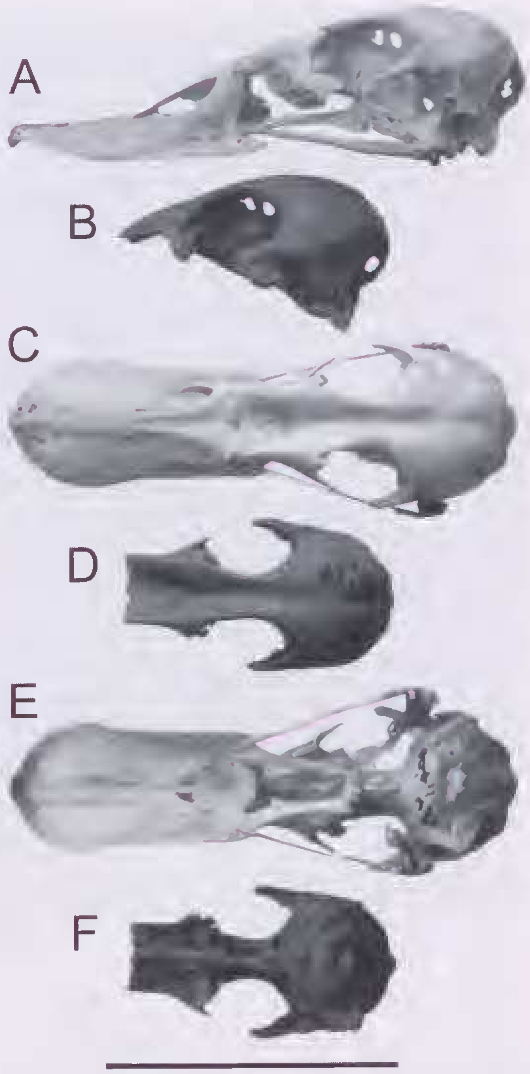

FIG. 9. Cranium of *Oxyura australis* CM Av31408 (A,C,E) compared to that of *O. vantetsi* MNZ S41197 (B,D,F).

The femora referred to *O. vantetsi* differ from *O. australis* as follows. They are smaller at 40.1-42. mm long (Table 4). The caput femoris is direeted proximally and cxtcnds proximad of the crista trochanteris, it does not in *O. australis*. The ridge bounding the fossa popilitea medially is convex medially rather than straight.

TABLE 5. Measurements (mm) of tibiotarsi of *Oxyura* species. *O. australis* CM and AM specimens, and summary statistics for *O. vautetsi* nsp (specimens MNZ S1083, 2247, 4298, 5776, 8348, 9632, 9976, 13688, 16540, 22170, 22172, 22173, 22174, 22175). Abbreviations as in Methods. DW is measured from the face of the lateral condyle, rather than from the prominence in the central proximal region of the condyle which would markedly increase distal width and which homologous protuberance is located more anteriorly in *Aythya*.

	TL	AL	PW	SW (mid)	SD (mid)	SW (min)	DW
Mean	69.08	66.12	8.39	4.52	3.14	3.84	8.96
Std Error	0.580	0.796	0.121	0.049	0.050	0.034	0.095
Std Deviation	0.820	1.593	0.342	0.163	0.167	0.101	0.232
Minimum	68.5	64.6	7.8	4.3	2.9	3.7	8.7
Maximum	69.7	68.3	8.8	4.7	3.4	4.0	9.4
Count	2	4	8	11	11	9	6
CM Av31408	77.3	69.1	8.7	4.5	3.0	4.1	10.0
AM O65518	76.0	68.7	8.6	4.4	3.1	4.0	9.7

Tibiotarsus (Fig. 6). Sixteen tibiotarsi (Table 5) were referred to *Oxyura vautetsi* because of their similarity to those of *O. australis*. They have a broad flat shaft characteristic of diving ducks, but differ from those of *Aythya novaeseelandiae*, which is the most similar taxon in New Zealand, and are similar to *Oxyura* as follows. The bone is broader, especially at the proximal and distal ends than in *Aythya*, the distal end is more inflected medially, and the shaft is more flattened. The crista cnemialis is much more elevated above the articular surfaces and the ridge leading from the crista cnemialis cranialis down the medial facies is markedly inflected medially centred opposite the top of the crista fibularis (such an inflected ridge is absent in *Aythya*). The sulcus extensorius is broad and flat in its base (narrow in *Aythya*). The cond. medialis has a large robust prominence in the centre of its medial face (small prominence in *Aythya*) and its proximocranial region is expanded proximally so that in medial view there is a marked hollow in the profile between the shaft and the condyle (forms a wider angle in *Aythya*).

Tibiotarsi of *O. vautetsi* are smaller than those of *O. australis* (Table 5) and differ further by the following. The crista cnemialis lateralis continues as a prominent ridge down the facies cranialis adjacent to the upper 30% of the crista fibularis, whereas it does not in *Aythya* or in *Oxyura australis*. But in the latter, the facies cranialis is swollen adjacent to the *crista fibularis*, which with the marked ridge leading to the crista fibularis, creates a marked elongate sulcus in the upper part of the shaft region similar to that seen in *O. vautetsi*. The cond. medialis in *O. vautetsi* is more rotated proximocranially than in *O. australis*.

Tarsometatarsus (Figs 7, 8) The tarsometatarsi listed in Table 6 were referred to *Oxyura vautetsi* because of their similarity to those of *O. australis*. They are very short and have a flattened shaft and a compressed and caudally rotated trochlea metatarsi II characteristic of diving ducks. They differ from those of *Aythya novaeseelandiae*, which is the most similar taxon in New Zealand, and are similar to *Oxyura* as follows. While of similar length to *Aythya* tarsometatarsi (Appendix 1), they are much broader across both ends and the shaft. In dorsal aspect, the sulcus extensorius is larger, and is bound laterally by a higher and sharper ridge than in *Aythya*. The junction of the caudal and medial facies has a distinct sharp ridge extending from the crista medialis hypotarsi to about mid-length that is very much less distinct in *Aythya*. The cotyla medialis is markedly offset medially from the line of the shaft. Medially, there is a deep sulcus formed between the cotyla medialis and the crista hypotarsi medialis, compared to this region being convex in *Aythya*. The crista hypotarsi medialis draws to a point distally that is rolled over the adjacent crista intermediate hypotarsi (it is not rolled over the adjacent crista and is distally hooked in *Aythya*). The foramen vasculare distale is larger than in *Aythya*.

Tarsometatarsi of *O. vautetsi* differ from those of *O. australis* by their smaller size. They differ also in having a shallower sulcus on the lateral half of the plantar surface of the distal third of the shaft. This sulcus is in part created by a low ridge that defines a 'lens-shaped' flat surface on the lateral face. Distally this low ridge approaches

TABLE 6. Measurements (mm) of tarsometatarsi of *Oxyura* species. *O. australis* CM and AM specimens, and summary statistics for *O. vantetsi* (specimens MNZ S8684, 13358, 14692, 22176, 22178, 22177). Abbreviations as in Methods.

	TL	PW	SW (midpoint)	SD (midpoint)	DW (parallel to lat side)	depth trochlea 3
Mean	34.18	9.30	5.09	3.18	8.36	5.80
Std Error	0.474	0.150	0.145	0.110	0.129	0.041
Std Dev	0.948	0.260	0.354	0.269	0.223	0.082
Minimum	33.0	9.1	4.5	2.8	8.1	5.7
Maximum	35.0	9.6	5.4	3.6	8.5	5.9
Count	4	3	6	6	3	4
CM Av31408	35.3	9.7	5.3	3.3	8.9	6.5
AM O65518	35.9	9.6	5.0	3.1	9.1	6.3

the dorsal face of the bone forming a sulcus greater than half the shaft depth in *O. australis*, whereas in *O. vantetsi*, this sulcus is shallower being less than half shaft depth. *O. australis* has relatively deeper trochlea compared to their width, especially for trochlea metatarsi III, than has *O. vantetsi*.

Skull elements (Fig. 9) One complete cranium (MNZ S41197) and one partial cranium (MNZ S20222) were identified from among the Lake Poukawa anatid bones. The skull of *Oxyura* differs markedly from those of all *Anas* species and *Aythya* in several features: notably there is an ossified septum between the nares (none in *Anas*, *Aythya*); the palate lacks a large oval foramen in the cranial end of the premaxilla; but most notably it has an ossified os ectethmoidale, that is fused in its lower half to the os lacrimale, and which has an ossified chamber attached to it anteriorly (the os ectethmoidale is not ossified in *Anas* and *Aythya*). Other than these features, skulls of *Oxyura* are characterised by the following. The os frontales, in the area between the os lacrimales, are deeply depressed forming a deep groove that extends posteriorly to behind the orbits (shallow sulcus in *Aythya*). The interorbital width is markedly less than frontal width. The preorbital processes are large with parallel dorsal and ventral margins (small points in *Aythya*). The ventral process of the os lacrimale is broad and aligned horizontally (narrow and directed ventrally in *Aythya*). The postorbital process is large. In posterior aspect, the crista nuchalis transversus is prominent and extends from the proc. paroccipitalis up over the occipital area in a continuous curve that approaches half of a circle (in *Aythya* this ridge forms a straight line along the rear margin of the fossa temporalis, then at the top of the fossa it abruptly angles towards the midline to meet in the middle, creating a quadrangular appearance). The proc. paroccipitalis, in posterior view, is larger and more robust than in *Aythya*, and in ventral view, each connects to straight, convergent, anterolateral ridges that form the ventral margin of the tympanic cavity. In *Aythya* these ridges have a very different shape: from the tip of each proc. paroccipitalis they extend anteriorly parallel to each other then form a curved and upturned flange that extends into the floor of the tympanic cavity. Thus, in lateral view, the tympanic cavity is dorsoventrally narrower with a distal ventrocaudally directed pocket. In *Oxyura*, the flat floor to the tympanic cavity results in it being nearly as high as long with no pocket. In *Oxyura*, the lamina parasphenoidalis is essentially flattened across its whole width whereas in *Aythya* there is a distinct medial rounded ridge protruding ventrally. Also, in *Oxyura* the horizontal lamina parasphenoidalis terminates caudally in a slightly transversely curved, abrupt angle, where it joins to the steeply rising posterior face of the os basioccipitale below the cond. occipitalis. *Aythya* differs markedly, as each side of the lamina parasphenoidalis joins to the foramen magnum above it in a continuous curve, and there is a circular sulcus below the cond. occipitalis and caudad of the medial ridge on the lamina parasphenoidalis, which results in an indented caudal margin to the basicranium.

The cranium S41197 has all the above characteristics of *Oxyura* crania and differs in relatively minor ways from that of *O. australis*. It is smaller (Table 7), and the central groove on top of the cranium is not as deep caudad of the point of minimum interorbital width, and the os ectethmoidale is more at right angles to the rostrum parasphenoidales. The posterior cranium

TABLE 7. Measurements (mm) of crania of *Oxyura* species. *O. australis*, CM and AM specimens, and *O. vantetsi*, MNZ specimens.

Measurement	MNZ S41197	MNZ S20222	AMO 65518	CMAv 31408
Length from prominentia cerebellaris to frontal-nasal hinge	44.9		47.5	48.2
Width across frontals at frontal-nasal hinge	11.5		13.4	12.8
Minimum width across frontal lacrimal complex	11.4		13.2	12.1
Preorbital width	14.3		15.5	15.5
Minimum interorbital width	6.9		7.3	7.7
Width across proc. postorbitalis	25.2		27.4	27.7
Width between os squamosi at top of cavitas tympanic	21.9		24.0	24.4
Width between proc. paroccipitales	20.6		22.3	22.4
Height from lamina parasphenoidalis to the top of the crista nuchalis transverses	19.6	19.6	20.7	21.0

(S20222) has the characteristic rounded alignment to the crista nuchalis transverses.

Sternum The single anterior fragment of a sternum is referred to *Oxyura vantetsi* as the sulci artic. coracoideus are arranged more or less at right angles to the carina sterna as in *Oxyura* and *Aythya* (whereas they form a concave anterior profile in *Anas*), and it lacks a centrally placed foramen pneumaticum dorsally caudad of the anterior margin (*Aythya* has a large foramen). The fragment lacks a prominent flattened spina externa (ventral manubrial spine) as seen in *O. australis*. The depth of the carina sterna (keel) measured from the dorsal surface between the sulci artic. coracoideus to the ventral side of the pila carinae so that one calliper is flat on the ventral surface of the carina is 14.5mm (18.2mm in CM Av31408). This small size is as expected from the relatively smaller size of other known elements.

DISCUSSION

At present, only larger or more robust elements of the skeleton are known for *Oxyura vantetsi*. There are many carpometacarpi, scapulae and radii of small anatids in the Poukawa collection. Examination of carpometatcarpi and scapulae failed to reveal any bones referable to *O. vantetsi* based on features seen in *O. australis*, although it is possible distinguishing features between *Aythya novaeseelandiae* and *Oxyura vantetsi* are lacking in these elements. However, relatively few of these elements were referred to *Aythya novaeseelandiae*, which may relate to their relatively small size and recovery techniques used in the excavation: small bones and bones of small taxa are rare in the collection. Therefore, as these elements in *Oxyura* would be even smaller than those of *Aythya novaeseelandiae*, their absence may be due to their relative rarity and sampling bias. It is possible that *Oxyura* radii lie unidentified among the Poukawa radii that are labelled as 'anatid', but distinguishing smaller anatids and particularly *Aythya* from *Oxyura* in this element was not considered feasible.

Addition of a new species and genus to the Holocene avifauna of New Zealand is unexpected given the extent of the resource and number of prior studies on such material; (Worthy & Holdaway, 2002). However, the wealth of material from cave, dune and swamp deposits masks a general lack of lacustrine faunas known from New Zealand, and it is indeed obligate lacustrine species such as *Biziura delautouri* and *Malacorhynchus scarletti* that are among our rarest species (Worthy, 2002; Worthy & Gill, 2002). Thus the present description of *Oxyura vantetsi* adding a new genus and species to the lacustrine fauna of the Holocene avifauna is not so remarkable. A total of 20 species in 12 genera are now known for Recent waterfowl in the New Zealand region, of which 10 species and 7 genera are now extinct from the region (Table 8). A further species, *Cygnus atratus*, was extirpated from New Zealand prehistorically, but was reintroduced historically, so preserving this taxon in New Zealand waterways. The extinctions have been biased towards the primitive taxa which are mainly monotypic or low-diversity genera, and which were probably the remnants of the original anatid radiation in the Australasian region.

The descriptions and comparisons made here suggest *Oxyura vantetsi* differed in relatively minor ways from the Australian *O. australis*, mainly in smaller size and a few skeletal features. There is no indication that *O. vantetsi* had reduced powers of flight, as so many New Zealand endemic taxa including waterfowl do. However, neither would such be expected, as *Oxyura* species typically are wholly aquatic and specialised diving ducks (Marchant & Higgins, 1990), and as such would require flight to travel between widespread suitable habitats. Until further lacustrine faunas are investigated in New

TABLE 8. List of the waterfowl known to have inhabited the New Zealand region during the Holocene. * indicates extant species.

Species	Common name
Biziura delautouri Forbes, 1892	New Zealand musk duck
Oxyura vantetsi sp. nov.	New Zealand blue-billed duck
Cnemiornis calcitrans Owen, 1865	South Island goose
Cnemiornis gracilis Forbes, 1892	North Island goose
Cygnus atratus (Latham, 1790) reintroduced	Black swan
Tadorna variegata (Gmelin, 1789)*	Paradise shelduck
Tadorna undescribed species	Chatham Island shelduck
Malacorhynchus scarletti Olson, 1977	Scarlett's duck
Pachyanas chathamica Oliver, 1955	Chatham Island duck
Mergus australis Hombron & Jacquinot, 1841	New Zealand merganser
Chenonetta finschi (Van Beneden, 1875)	Finsch's duck
Anas gracilis Buller, 1869 *	Grey teal
Anas chlorotis G.R. Gray, 1845 *	Brown teal
Anas aucklandica (G.R. Gray, 1844)*	Auckland Island teal
Anas nesiotis (J.H. Fleming, 1935)*	Campbell Island teal
Anas sp. undescribed sp.	Macquarie Island teal
Anas rhynchotis Latham, 1801	Australasian shoveler
Anas superciliosa Gmelin, 1789	Grey duck
Hymenolaimus malacorhynchos (Gmelin, 1789)	Blue duck
Aythya novaeseelandiae (Gmelin, 1789)	New Zealand scaup

Zealand it is unlikely that the range of *O. vantetsi* will be well known. The bones known from Lake Poukawa suggest it was far less abundant than waterfowl such as *Anas superciliosa*, *A. chlorotis*, *A. rhynchotis* and *Aythya novaeseelandiae*, but more common than *Biziura delautouri* and the dabchick *Poliocephalus rufopectus* or crested grebe *Podiceps cristatus*. As *Oxyura* species are typically gregarious (Marchant & Higgins, 1990), *O. vantetsi* was unlikely to have been a rare species. The presence of a single bone of apparent South Island origin (CM Av10777) indicates this species was distributed in South Island waterways and so should be looked for in any wetland assemblage. In view of its ability to disperse, and that *O. australis* readily uses shallow inshore marine waters, saline lagoons, and estuaries (Marchant & Higgins, 1990), the former presence of *O. vantetsi* on Chatham Island cannot be discounted either, as in now known to be the case for *Malacorhynchus scarletti* (Worthy & Gill, 2000).

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APPENDIX 1. Summary statistics for measurements of *Aythya novaeseelandiae* from specimens listed above. Abbreviations as in Methods.

	Hum L	Hum PW	Hum SW	Hum DW	Ulna L	Ulna PW	Ulna SW	Ulna DW	Radius L	Radius Dist	Cmc L	Cmc PW	Cor L
Mean	72.1	15.4	5.2	10.4	61.1	7.1	4.0	6.9	57.3	4.6	38.2	9.1	38.3
Std Error	0.779	0.144	0.068	0.074	0.441	0.055	0.101	0.121	0.499	0.049	0.220	0.052	0.397
Std Dev	2.463	0.456	0.214	0.234	1.463	0.181	0.335	0.401	1.577	0.156	0.730	0.172	1.257
Minimum	69.0	14.8	4.9	10.0	59.3	6.9	3.8	6.5	55.1	4.4	37.4	8.8	36.2
Maximum	76.7	16.1	5.5	10.7	63.2	7.4	4.9	8.0	59.3	4.9	39.2	9.4	40.2
Count	10	10	10	10	11	11	11	11	10	10	11	11	10

	Femur L	Femur PW	Femur SW	Femur DW	Tibia TL	Tibia PW	Tibia SW	Tibia DW	Tmt L	Tmt PW	Tmt SW	Tmt DW
Mean	43.1	9.9	4.0	9.6	74.2	7.4	3.6	8.0	34.6	8.1	4.1	8.4
Std Error	0.581	0.093	0.053	0.153	0.680	0.069	0.044	0.112	0.355	0.129	0.052	0.126
Std Dev	1.839	0.293	0.168	0.484	2.255	0.228	0.147	0.373	1.122	0.407	0.163	0.398
Minimum	40.3	9.5	3.8	8.6	71.8	7.0	3.3	7.5	33.0	7.0	3.8	7.8
Maximum	46.0	10.4	4.3	10.0	79.7	7.7	3.8	8.9	37.1	8.4	4.3	9.1
Count	10	10	10	10	11	11	11	11	10	10	10	10